Development of Double Acting Deep Drawing Press

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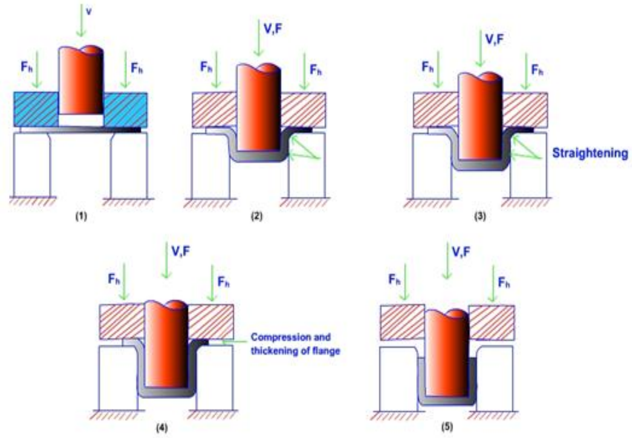
Abstract - *The existing method of manufacturing the capacitor cap is brazing. This process is complicated and consumes much time. It also results in wrinkles on the surface of capacitor cap. Many times the product breaks which results in rejection of the product. So it is requirement of company, that a new mechanical system should manufacture cylindrical component i.e. capacitor cap without wrinkles and the outside covering of cap should not break due to excess stress and also higher the conductivity of product. The operation which can fulfill this requirement is deep drawing machine. So the technology of Double Action Deep Drawing Hydraulic Press Machine is developed. Machine will offer the product with high accuracy and within less time. It results in the lesser rejection and more finish product is obtained. For increase in rate of production of jobs usually of smaller size and simpler geometry double action deep drawing hydraulic press machines is preferably used.*

Key Words: **Deep Drawing, Blank Holding Force, Parameters, Components, Draw Force, etc.**

1. INTRODUCTION

Sheet Metal Forming

Sheet metal forming is used to produce various products from mild steel, stainless steel, copper, aluminium, gold, platinum, tin, nickel, brass and titanium. To reduce costs and increase the performance of manufactured products, more and more lightweight and high strength materials have been used as a substitute to the conventional steel. These materials usually have limited formability, thus, a thorough understanding of deformation processes and the factors limiting the forming of sound parts is important, from both engineering and economic viewpoints. In sheet metal forming, a piece of material is plastically deformed between tools to obtain the desired product. Sheet metal forming is characterised by the conditions in which the stress component normal to the plane of the sheet is generally much smaller than the stresses in the plane of the sheet. The common defects that occur in sheet metal forming are wrinkling, necking, scratching and cracks. Wrinkling occurs in areas of high compressive strains and necking in areas with high tensile strains. Scratching is caused by defects on the tool surface and orange peel may occur after excessive deformation depending on the grain size of the material.



Stages in Deformation of the Work in Deep Drawing

1) Punch makes initial contact with work
2) Bending
3) Straightening
4) Friction & Compression

Final cup shape showing effects of thinning in the cup

Deep Drawing Measures

One of the most important measures of deep drawing operation is the limiting drawing ratio LDR. Limiting drawing ratio is defined as the maximum ratio of blank sheet diameter to punch diameter that can be drawn under ideal conditions in one stroke without failure.

That is,

$$LDR = \frac{Dbmax}{Dp}$$

An approximate upper limit on the drawing ratio is a value of 2.

Another measure of drawing is the reduction, which is defined as

$$Re = \frac{Db}{Db} - \frac{Dp}{Db} = (1) - \frac{1}{LDR}$$

The reduction is closely related to and its value should be less than 0.5. A third measure of deep drawing operation is the thickness to diameter ratio", $LDR = t/D_b$, This is often expressed as a percent. It is preferable that t/Db ratio to be greater than 1%. As t/D_b decreases, the tendency for wrinkling increases. In fact, the punch – to – die clearance is usually some 10% larger than the sheet thickness to accommodate blank thickening during the drawing process. Thus, the clearance can be expressed as

$$C = 1.1t$$

The Drawing Force

The force in the punch required to produce a cup is the summation of the ideal deformation force, the frictional forces, and the force required to produce ironing. Figure shows the relation between the draw force and the draw stroke.

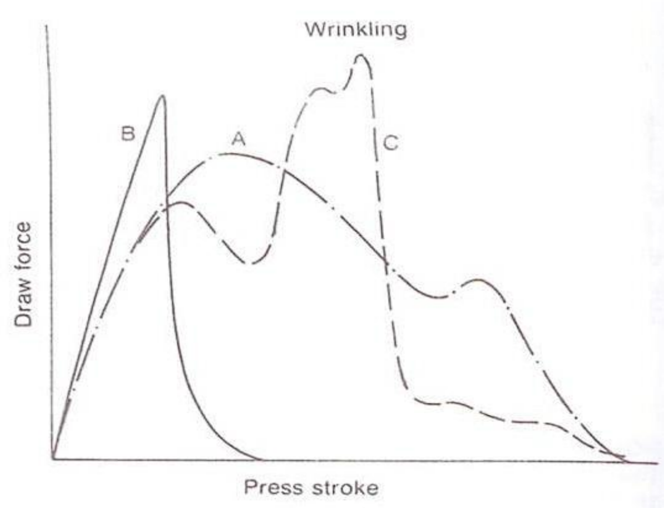


Fig: Punch Force vs. Punch Stroke for deep drawing. Curve a typical of drawing with optimum plank holder pressure

The following equation has been developed to approximate the total punch force to deep draw a blank of D_b, at any stage in the process is,

$$F = \left[\pi \times D_p \times t(1.1\sigma_{Avg}) \times \ln\frac{D_b}{D_p} + \mu\left(2 \times F_h \frac{D_b}{D_p}\right)\right] \times \exp\left(\mu \times \frac{\pi}{2}\right) + B$$

Where:

F= total punch force, 6avg= the average flow stress, d= punch diameter, D= blank diameter. F_h= blank holding force, B= force required for bending and unbending blank, t= wall-thickness. μ= coefficient of the friction. However, equation is somewhat difficult to deal with because of the many variables involved in the operation and because deep drawing is not a steady – state process. Hence, an approximate equation of the maximum punch force has been developed as F,

$$F = \pi D_b t(UTS) \times \left(\frac{D_b}{D_p} - 0.7\right)$$

In which:

F= maximum drawing force, in lb, (N). t = original blank thickness, in (mm), UTS= ultimate tensile strength, (MPa).D_b, D_p = are the starting blank diameter and punch diameter in (mm), respectively. The drawing force F varies throughout the downward movement of the punch, usually reaching its maximum value at about one-third the length of the punch stroke.

Blank Holding Force

The holding force F_h plays an important role in the deep drawing. As a rough approximation, the holding pressure can be set at value equals 0.015 of the yield strength of the sheet metal. Thus by multiplying the holding pressure by the portion of the starting area of the blank which is to be held by the blank holder, we can estimate the holding force (F_h) as,

$$F_h = 0.015 S_y \pi\left[D_b^{\,2} - \left(D_p + 2.2t + 2R_d\right)^2\right]$$

Where, F_h = maximum holding force in deep drawing, lb, (N), S_y = yield strength of the sheet metal (MPa), R_d = die corner radius, in (mm).

Tooling and Equipment

A double-action mechanical press is generally used for deep drawing, hydraulic presses are also used. The double action press controls the punch and blank holder independently and forms the part at a constant speed. Since blank holder force controls the flow of the sheet metal within the die, now presses have been designed with variable blank- holder force. In these presses the blank holder force is varied with punch stroke.

The most important factor in the die design is the corner radius (Rd) of the die. This radius must have an optimum value since the material is pulled over it. The value for the optimum radius of the die depends upon the print requirement and the type of the material being drawn. Obviously, the smaller the die radius, the grater the force needed to draw the cup. The radius of the die may be between four to eight times the thicknesses of the blank. That is R_d.

$$4t \le R_d \le 8t$$

Practically, it is recommended to start with Rd equal 4t and increase it if necessary. Similarly, the punch nose radius (R_p) is important since it shapes the radius of the bottom of produced cup. If R_p is too small, the bottom radius of the cup may tear out. It may be necessary to make the radius larger than needed, and reduce its size in subsequent drawing operations. As a start, a 4t radius –to- blank thickness may be used.

Cup Specifications & Drawing & Holding Force Calculations

The DDM was designed to produce cup-shaped parts in a single stroke, as stated earlier, the purpose of designing the DDM is to provide the manufacturing processes lab at An-Najah University with an apparatus that can demonstrate the deep drawing process and also be used by students to perform some basic experiments related to the deep drawing process. Actually, in order to design a proper DDM, it is necessary first to determine the product (the cup) specifications, drawing force and holding force.

Cup Specifications

The product of the required DDM is chosen to be a simple cup having a certain inner diameter (d) and depth (h) and to be produced using a sheet metal of thickness (t). The dimensions of the cup must be selected such that the deep drawing operation is feasible to produce the cup in single stroke; to measure the feasibility of the operation, the LDR, thickness-to-diameter ratio (t/D) and the reduction (Re) percentage must satisfy the feasibility conditions mentioned in section2 of this paper. To do so, It was decided that the thickness of the sheet metal to be used in producing the cup is t=0.5mm, hence -based on the recommendations stated in section 2 the corresponding die radius is R_d= 2t= 2, punch radius is R_p= 2t=2, and the clearance (C) corresponding to t= 0.5mm is 1.1t= 0.5mm. It was also decided that the final cup would have a depth of 55mm and inner diameter d of 74 mm. The part is shown in figure. Now, the blank diameter D_b can be calculated using the following formula

$$D_{b=}\sqrt{d^2 + 4d(H - 0.43r)}$$

In which d= cup mean diameter, in (mm). H= mean high of the cup's shell, r = radius at neutral bend line. Using equation (8) and the cup dimensions of figure 3, D_b is calculated to be D_b= 148 mm. With D_b= 148mm, one can show that the three drawing feasibility measures are satisfied and the cup can be produced in a single stroke.

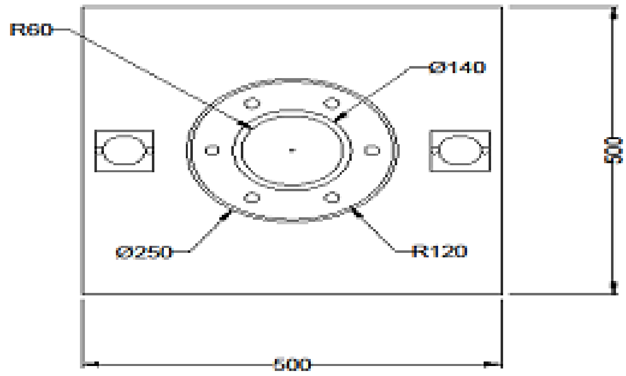
Determination of Drawing Force and Blank Holding Force

The cup is to be produced from C 11000 with. UTS = 380 MPa, Sy= 120 MPa Using equation with D_p = 74 mm; one can calculate the drawing force to produce the cup as F = 96.66 KN. Similarly, from equation (6) F_h = 88.43 KN. So the total drawing force (F_d) to be applied by the DDM equals the summation of F and F_h, that is F_h = 88.43 KN. For design purposes of DDM elements; the F_d shall be multiplied by a load factor equals to 1.6.

Components to be Designed

Top Plate

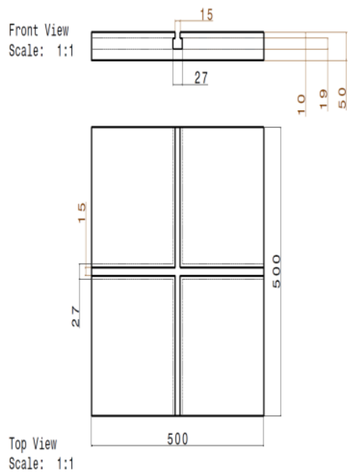
It is the plate which is situated at the top of the machine. It will be made up of MS material. This plate will support the one cylinder which is use for punching the work piece. This plate will also support two small cylinders which are situated beside the punching cylinder. It will hold four pillars which will be fixed with the help of bolts. It will support whole weight of three cylinders which are used for different purposes in machine. It also will help to correct alignment of base plate and pressure plate with four rods at its end.



Top View of top Plate

Base Plate

It is a plate which is situated on the frame. It will take all load of machine. It is connected with the top plate with the help of four pillars. That pillars are situated at its ends. It has T slot cut in to it. This T slot helps for mounting die set on it. It is the plate on which work piece is actually placed and then punching operation take place. An ejection system will be provided below it to eject the work piece from the die set.

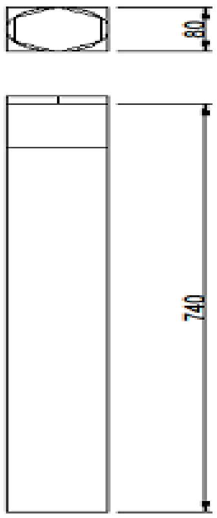


Pressure Plate

Pressure plate is little less in dimension than base plate or top plate as it has to move up and down in the machine. This plate will move up and down with the help of two piston rod which will hold it at the two ends. This plate will hold the metal sheet and then the punch will come down and punch the metal sheet. It has center hole through which punch moves up and down. This is important part of system as it has to hold the metal sheet. Due to this plate there are fewer chances of wrinkles on the work piece.

Pillars

There are total four pillars in this machine. These pillars are mounted between top plate and bottom plate. They are fixed with top and bottom plate with bolt arrangement. They support whole weight of cylinders and top plate. They reduce vibrations of the machine to transfer to the base plate and ultimately to the die set. This avoids any variation in the work piece.



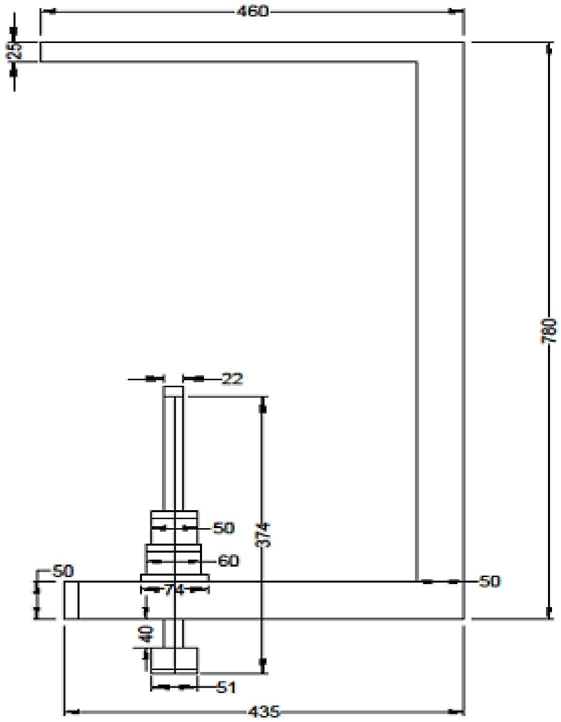
Front view of Pillar

Frame

This is the component of the system which takes all load of machine. This take load of hydraulic cylinders, base plate, top plate, pillars. It also holds ejection system which helps in ejection of the work piece from the die set.

C-Clamp

This component of the system helps in ejection of the work piece from the die. It is also limit the movement of pressure plate. This C- clamp is connected to the piston rod of punching cylinder. It also has one limiting movement mechanism. With this mechanism the armature of C-clamp is made contact with pressure switch is used to stop the C-clamp.



Front view of C-Clamp

Construction

The materials used in this project are detailed as follows

Mild steel

The machine is basically made up of mild steel.

Reasons

1. Mild steel is readily available in market.
2. It is economical to use.
3. It is available in standard sizes.
4. It has good mechanical properties.
5. It has moderate factor of safety.
6. It has high tensile strength.
7. Low co-efficient of thermal expansion.

Properties of Mild Steel

M.S. has carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only. They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases. Mild steel serves the purpose and was hence was selected because of the above purpose.

Construction & Working

Double Action Deep Drawing Hydraulic Press Machine Automation plane uses hydraulic cylinder for both direction movement and stroke, hydraulic motor is used to drive the hydraulic cylinder and pleasure switch to control the movement of press pad and punch.

Solenoid valves are widely used on compressed air or hydraulic fluid for powering actuators on mechanical components. While motors are used to supply continuous rotary motion, actuators are typically a better choice for intermittently creating a limited range of movement for a mechanical component, such as moving various mechanical arms, opening or closing valves, raising heavy press rolls, applying pressure to presses. Control circuits are often drawn using ladder logic, so named because the wiring diagram resembles a ladder. First of all base plate is mount on the frame. Base plate is weld to frame. Then take four pillars and they were situated vertically on the base plate and in they are fitted to the base plate with help of bolt and lock nut. Over that pillar the top plate is situated and it is fixed with the nut and bolt. After that the round plate is welded to the top plate at its center. Over that round plate cylinder of 20 tones is fixed with nut and bolt. Which are situated in the holes on the circumference of the round plate.

After this situation of the center cylinder which is used for punching operation. Then and edges of top plate square blocks are welded and over that block cylinder of 2.5 tones is fixed. With the same process that of center cylinder. After that piston of cylinder which is of 2.5 tones brought down and pressure plate is fixed with it at the edges and with help of square block. In that Allen bolts and nut. After that c-clamp is situated in the center cylinder piston by cutting and milling it into that shape. Another part of c-clamp is assembling top the ejection system. Which is situated below the base plate Pressure switch is situated on the top plate for to limit the movement of c-clamp in the upward and downward direction. The hydraulic system is brought near the machine and its pipes and ports are connected to the vales of the cylinder. There is the system of switches. White switch is for the downward movement of center piston which acts as the punch. And black switch is for downward movement of pressure plate with the help of downward movement of side pistons. Red switch is for upward movement center piston which acts as a punch. Blue switch is for upward movement side piston which acts move pressure plate.

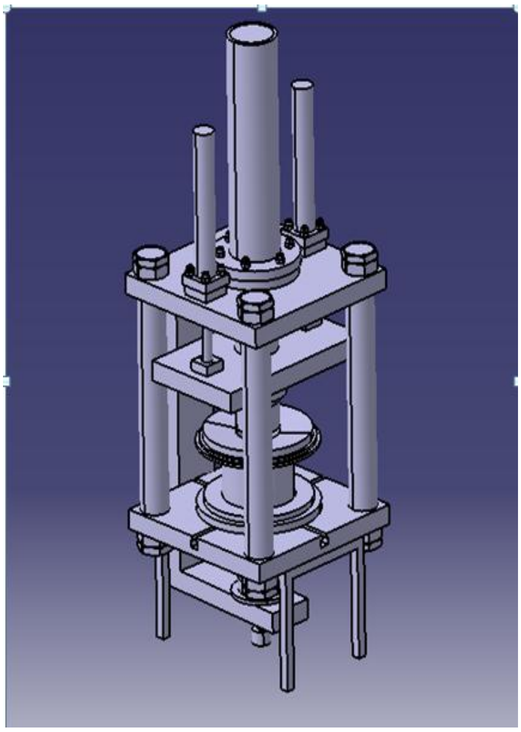


Fig. Assembly of Components

Feedback control

Feedback control is accomplished with a controller. To function properly a controller must provide correction in a manner that maintains stability. Maintaining stability is a principle objective of control theory.

Sequential control and logical sequence control

Sequential control may be either to a fixed sequence or to a logical one that will perform different actions depending on various system states. An example of an adjustable but otherwise fixed sequence is a timer on pressure switch. In a typical hard wired motor start and stop circuit (called a control circuit) a motor is started by pushing a "Start" or "Run" button that activates a pair of electrical relays. The "lock-in" relay locks in contacts that keep the control circuit energized when the push button is released. (The start button is a normally open contact and the stop button is normally closed contact.) Another relay energizes a switch that powers the device that throws the motor starter switch (three sets of contacts for three phase industrial power) in the main power circuit. All contacts are held engaged by their respective electromagnets until a "stop" or "off" button is pressed that de-energizes the lock in relay. (Note- Large motors use high voltage and experience high in-rush current, making speed important in making and breaking contact. This can be dangerous for personnel and property with manual switches.

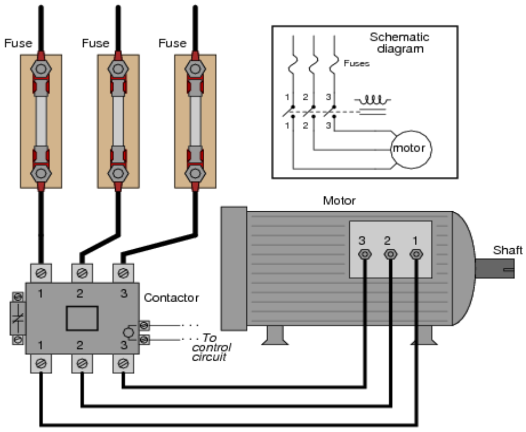


Fig. Logic Control Automation

CONCLUSION

The project was carried out to reduce machining time of double action deep drawing Hydraulic press machine. From the design calculations and analysis the following conclusions for machining of high accurate product with very low cost Double Action Deep Drawing Hydraulic Press Machine can be carried out.

- The machine substantially reduces the machining time with high grade accuracy.
- Productivity increases about 2 times.
- The machine increases the productivity.
- The machine is of robust design and easy to operate.
- Cost reduction.
- Dependency is less.

From this project we conclude that the machine is suitable for mass production and high grade accuracy. As it is simple in construction and easy to operate it reduces human effort.

Future Scope

Robotic Arm: Currently the die is placed on the base plate manually. In future Robotic Arm will be used to place the die on the primary and secondary die and will automatically remove that product after machining.

Dust Collector: As the machining is done to remove very fine material, that fine material and oil will cause disturbances in functioning of the machine. To avoid it Dust collector will be introduced in machine to collect that fine material (Burr) removed from the plate.

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